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ABSTRACT

The effect on reading speed of the number of target items being searched for and the number of target occurrences in the text was examined. The subjects, 24 college undergraduate volunteers, were presented with a list of target words, and then they read a passage for comprehension which contained occurrences of the target words (Experiment1) or close associates of the target words (Experiment 2). The number of target words (1, 2, or 4) was combined factorially with the number of occurrences (0, 1, 2, or 4) in a within-subjects design. In both experiments, reading speed was affected only by the number of words in the target list. Neither of the variables had any effect on comprehension. The results indicated that central memory load limits reading speed, but scanning and decoding processes are so automated that they are unaffected by the additional tallying operation required of the subjects in this task. Tables and references are included. (Author/VJ)

VISUAL SEARCH AND READING

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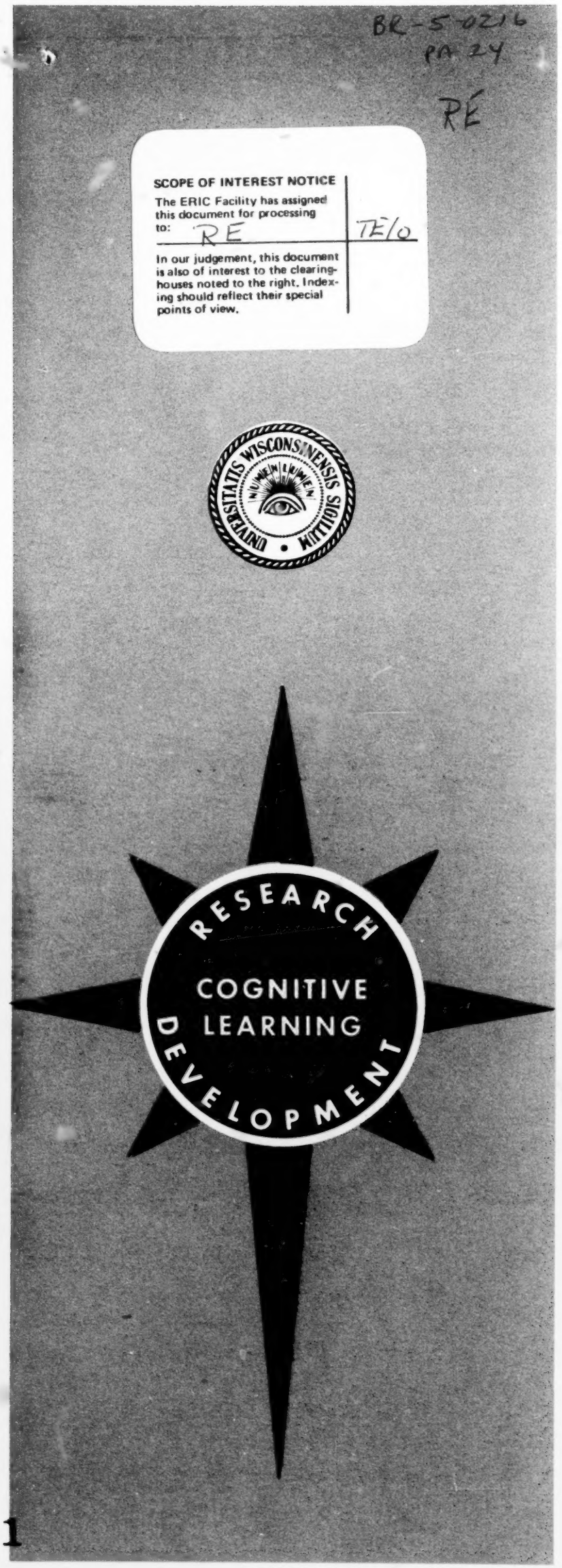

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Technical Report No. 170

VISUAL SEARCH AND READING

By Robert C. Calfee* and Penny Jameson

Report from the Project on Reading and Related Language Arts
Basic Pre-Reading Skills: Identification and Improvement

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The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Basic Prereading Skills: Identification and Improvement element of the Reading and Related Language Arts Project, in Program 2, Processes and Programs of Instruction. General objectives of the Program are to develop curriculum materials for elementary and preschool children, to develop related instructional procedures, and to test and refine the instructional programs incorporating the curriculum materials and instructional procedures. Contributing to these Program objectives, this element has two general objectives: (1) to develop tests for diagnosing deficits in skills which relate to reading (2) to develop a kindergarten-level program, including diagnostic tests and instructional procedures, for teaching basic prereading skills. Tests and instructional programs will be developed for visual and acoustic skills, including letter and letter-string matching with attention to order, orientation and detail, and for auditory matching, segmentation, and blending.

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ABSTRACT

Subjects (Ss) were asked to look for occurrences of words from a target list while reading a passage for comprehension. Number of target words (1, 2, or 4) was combined factorially with number of occurrences (0, 1, 2, or 4) in a within-Ss' design. In Experiment I, Ss searched for the specific words in the target list, in Experiment II for any close associate of words in the target list. In both experiments, reading speed was affected only by the number of words in the target list. Neither of the variables had any effect on comprehension. The results indicate that central memory load limits reading speed but scanning and decoding processes are so automated that they are unaffected by the additional tallying operation required of S in this task.

I
INTRODUCTION

Experiments on visual scanning and search by Neisser (1967, ch. 5) resemble in certain ways the process of reading in literate adults. In one of the more intriguing studies along this line, Neisser and Beller (1965) asked Ss to scan a list for a meaningful word (Monday) or for words falling in conceptual classes such as states of the Union, proper names, or animals. They found that the rate of search for a closed conceptual class was only slightly greater than for a single word —Ss searched through a list at a rate of .07 sec./word for Monday and .11 sec./word for states. Rate of search for animals (an open conceptual class) was slower, about .18 sec./word.

In reading, S can use context to predict particular words or classes of words which are likely to occur. To the extent that a skilled reader makes such predictions, rapid scanning for the "target" words should be possible, thereby facilitating speed of reading. Visual search studies have used letters or single words as stimulus materials and, hence, the results are not directly applicable to the processes involved in normal reading.

The present experiment was designed to explore operations similar to those in visual search but in a task more like normal reading. The question of primary interest concerned the effect on reading speed of the number of target items S was searching for and the number of target occurrences in text.

II
METHOD

GENERAL

Subjects (Ss) were presented a list of target words. Then they read a passage which contained occurrences of target words (Experiment I) or close associates of the target words (Experiment II). They were instructed to notice these occurrences while reading the passage as rapidly as possible. Comprehension of the passage was stressed. As soon as the passage was finished, the page was to be turned. The reading time was recorded by the experimenter (E). Ss wrote down the frequency of occurrence of each of the target words and then answered two multiple-choice questions testing comprehension of the passage.

DESIGN AND PROCEDURE

The basic design in both experiments was a 3 x 4 factorial within-Ss design. The two variables were (a) number of words in the target list (1, 2, or 4) and (b) number of occurrences of targets in the passage (0, 1, 2, or 4). For conditions with one word in the target list and two or four occurrences in text, the target word was repeated in the passage two or four times, respectively. For conditions with two words in the target list and with two or four occurrences in text, each target word occurred once or twice, respectively. For the condition with four target words and four occurrences in the passage, each target word occurred in the passage exactly once. For conditions in which there were fewer occurrences than there were target words, no target word occurred more than once in the passage; otherwise words were chosen at random from the target list.

The 12 conditions from the 3 x 4 factorial design were combined with 12 passages in a Graeco-Latin square, which was administered to two groups of 12 college undergraduates, volunteers from introductory psychology classes at the University of Wisconsin. Experiment I was conducted in Fall 1967 and Experiment II in Spring 1968. In Experiment II, a no-target control list was also included in a partly counterbalanced fashion in the square.

The passages were chosen from familiar works of fiction: e.g., All the King's Men by R. P. Warren, Death in Venice by Thomas Mann, the Ballad of the Sad Cafe by Carson McCullers, and You Only Live Twice by Ian Fleming. All passages were altered as necessary until they were approximately 100 words in length, not counting function words. Passages were also altered so that one common noun appeared four times in the course of the 100 words, and two common nouns twice each. Passages were originally selected to meet these requirements as closely as possible. Noun substitutes for pronouns were then introduced as necessary. All the common nouns that appeared as targets were high-frequency English words (Thorndike-Lorge AA or A). In conditions with more target words than occurrences, nonoccurring targets were compatible with the general sense of the passage but no target or close associate of a target appeared in text.

In Experiment II, the target list shown to S before he read the passage consisted of close associates of the occurrences in the passage, and S was instructed accordingly. Also, some modifications of the passages were made after Experiment I in an effort to render them more homogeneous but, as will be seen below, these efforts were not too successful. The words in the target list were of lower frequency than the occurrences, but were still reasonably common [at least 50 times per million, Thorndike-Lorge].

Ss were fully instructed as to the nature of the task. They were asked also for their grade-point average, to report any special reading training courses, and to rate themselves both as to speed and accuracy on normal reading.

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None of these measures bore any significant relation to performance on the task, and they will not be discussed further. Ss then received three practice trials on three lists similar to those used in the experiment proper. Following each practice list, they were asked if they had any questions. The 12 experimental passages were then given without any breaks. A session usually took less than half an hour.

Reading time was measured in centiseconds from the time Ss turned the page to begin reading until the page was turned over. On the test page which followed, the target list was reproduced, together with two multiple-choice questions. Ss wrote down the number of times they thought each of the target words occurred, and then answered two questions. In Experiment II, the words listed on the test page were those actually occurring in text rather than the associates in the target list to insure that S knew exactly which words to tally.

III
RESULTS

Four dependent measures were analyzed: (a) reading time, (b) number of words reported as a ratio to the number of occurrences, (c) the difference between the number of words occurring and number of words reported, and (d) number of correct answers on the comprehension test. Measures (b) and (c) represent different ways of looking at the same basic data; viz., the number of words reported as occurrences. There was no a priori way of determining which of these measures would be more interesting and so both were computed. However, they are not independent. For measure (b), the divisor was set equal to one when the number of occurrences was zero. The expected value of the score for perfect performance is zero for this level; whereas for the other levels of the target-occurrence variable, the expected value for perfect performance is one.

In Table 1 are presented the means for each of the variables, and Table 2 gives analysis of variance results for Experiment I. The corresponding results for Experiment II are in Tables 3 and 4. In general, the two experiments yield very nearly identical results. Reading speed is slower in Experiment II, and while it is tempting to speculate on the implications of this difference, it is true that the two studies were conducted in different semesters and hence possibly involved different S-populations. However, it may be that the additional burden of storing "associates" rather than explicit representations in memory is responsible for the slower reading rate. This interpretation is compatible with other aspects of the data.

The most interesting question concerns the relation between reading speed, memory load, and number of target items in the text. In both experiments, reading time increased significantly ($p < .001$) with increased memory load [the number of different items S had to keep in mind while reading]. Reading time for the no-target control passages in Experiment II was 40.7 sec., which when compared with the average reading time of 52.32 for the same passages with targets, provides further evidence of the effect of memory load on reading speed. However, performance was unaffected by the number of occurrences of target words that Ss presumably had to process or identify while reading. The interaction between memory load and number of occurrences was also a negligible source of variance. The natural interpretation is that Ss identified and tallied target items without any disturbance of the reading process. Moreover, Ss performed these identifications with equal facility whether searching for specific words or less well specified associates.

From Tables 1 and 3 it can be seen that memory load was also the primary variable in determining number of words reported, by either the ratio or difference measures. In part, this result reflects the fact that the number of words on the test list was equal to the number of items in the target list. The greater the number of test words, the more occurrences reported by S. Considering just the condition with four words in the Target List but no occurrences in the text, seven Ss in Experiment I and eight in Experiment II checked one or more of the test words as having been detected. When the Target List contained two words and there were no occurrences, two Ss in Experiment I and seven in Experiment II checked one of the test words and no Ss in Experiment I and two in Experiment II checked a test word when the Target List contained one word and there were no target occurrences. In short, the basic pattern of results for the two scores (ratio and difference) based on the number of words reported was this—Ss reported more words as memory load [and hence number of test words] increased but this effect was negligible by the time there were as many as four occurrences of target items in text. This result is probably

Table 1

Means of Dependent Variables for Each Experimental Condition in Experiment I

	Reading Time (Sec.) No. of Target Occurrences					No. of Targets Reported/ No. of Targets Occurring[a]					No. of Targets Reported- No. of Targets Occurring					Number Correct on Comprehension Test				
Memory Load	0	1	2	4	ave.	0	1	2	4	ave.	0	1	2	4	ave.	0	1	2	4	ave.
1	30.47	29.50	30.39	29.28	29.99	1.00	1.00	.75	.94	.92	.17	.17	-.50	-.25	-.10	1.25	1.50	1.25	1.33	1.33
2	32.37	31.61	32.70	32.58	32.32	.92	1.00	1.08	.97	.99	.25	-.17	.17	-.27	.01	1.08	1.17	1.42	1.33	1.29
4	34.05	33.10	33.24	33.86	33.56	1.33	2.33	1.79	.93	1.60	1.42	1.25	1.33	-.08	1.02	1.25	1.08	1.42	1.42	1.29
Average	32.29	31.40	32.11	31.90	31.96	1.08	1.44	1.21	.95	1.17	.61	.42	.33	-.20	.31	1.19	1.25	1.36	1.36	1.30

a) For 0 target occurrence, the denominator was set at 1.

Table 2

Analyses of Variance on Dependent Variables in Experiment I

Source	df	Reading Time F	Number Seen/ Number Occurring F	Number Seen- Number Occurring F	Number Correct Comprehension F
Subjects	11	27.7***	4.9***	7.0***	< 1
Order	11	< 1	1.9*	2.0*	< 1
Passage	11	4.4**	1.4	1.1	2.6**
Conditions					
Memory Load (ML)	2	8.1***	15.6***	16.8***	< 1
Number of Occurrences (NO)	3	< 1	3.8*	4.5*	< 1
ML x NO	6	< 1	3.5*	1.4	< 1
Residual Error	99	14.21	.42	1.03	.53

* $p < .05$ ** $p < .01$ *** $p < .001$

Means of Dependent Variables for Each Experimental Condition in Experiment II

Memory Load	Reading Time (Sec.) No. of Target Occurrences					No. of Targets Reported/ No. of Targets Occurring[a]					No. of Targets Reported- No. of Targets Occurring					Number Correct on Comprehension Test				
	0	1	2	4	ave.	0	1	2	4	ave.	0	1	2	4	ave.	0	1	2	4	ave.
1	49.69	50.19	44.95	50.53	48.84	.33	1.08	.88	.85	.79	.17	.17	-.25	-.58	.29	2.00	1.50	1.67	1.67	1.71
2	52.73	52.12	54.77	53.06	53.17	.71	1.08	.73	.98	.88	.58	.17	-.58	-.08	.35	1.83	1.42	1.58	1.25	1.52
4	57.50	53.62	55.30	53.33	54.94	1.08	2.29	1.32	1.02	1.43	1.00	1.33	.67	.00	.75	1.42	1.75	1.50	1.67	1.59
Average	53.31	51.98	51.67	52.31	52.32	.71	1.48	.98	.95	1.03	.58	.56	.50	.22	.47	1.75	1.56	1.58	1.53	1.61

a) For 0 target occurrence, the denominator was set at 1.

Table 4

Analyses of Variance on Dependent Variables in Experiment II

Source	df	Reading Time F	Number Seen/ Number Occurring F	Number Seen- Number Occurring F	Number Correct Comprehension F
Subjects	11	15.0***	< 1	< 1	< 1
Order	11	2.1*	1.5	1.5	< 1
Passage	11	6.7***	2.6*	2.6*	2.5
Conditions					
Memory Load (ML)	2	28.6***	70.4***	13.7***	6.3**
Number of Occurrences (NO)	3	< 1	34.8***	3.4*	3.9*
ML x NO	6	< 1	3.0*	2.4*	2.1
Residual Error	99	66.15	.33	.87	.28

* $p < .05$ ** $p < .01$ *** $p < .001$

due to the fact that non-occurring targets were selected to be compatible with the sense of the passage.

Analysis of variance of the comprehension scores revealed no significant effects of experimental conditions; nor did visual inspection of the means suggest any pattern to the comprehension data. Some of the passages were more difficult to comprehend than others, as can be seen in Tables 2 and 4. Also some of the passages took longer to read than others. However, there was no correlation between comprehension scores and reading time for the different passages.

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IV
DISCUSSION

The finding that memory load was a significant factor in reading speed indicates that central, cognitive processes involving the storage or maintenance of readily available information plays a critical role in performance of skilled readers. The fact that the number of occurrences of target items in text was unrelated to performance means that the processes involved in perceptual scanning and preliminary decoding are so rapid, so "automated," that recognition and tallying of words in text can be carried out without significantly slowing the rest of the reading act. Finally, the fact that these results hold whether S is looking for a word or some associate of a word suggests that the "high-speed" portion of skilled reading carries at least through some level of semantic decoding.

The involvement of central factors in performance on the experimental task is not too surprising—the absence of any effect of independent variables involving decoding processes, however, was unexpected. Also, it is somewhat difficult to reconcile the preceding interpretation with the negligible effects of any of the independent variables [in particular, memory load] on comprehension scores. One might suppose that comprehension would require some of the same processing operations as memory storage and, hence, would be influenced by memory load. One possibility is that S arranged a tradeoff—reading speed was adjusted as necessary to maintain a satisfactory level of comprehension. Another possibility is that the comprehension test procedure was not sufficiently sensitive, either because it was too easy or because the errors only reflected faulty test items. The passages were relatively short, and so there was not a great deal of content to measure. The multiple-choice tests used were aimed at specific facts in text and the distractors selected to be reasonably similar to the correct answer. In Experiment II, Ss were asked to write a synoptic sentence or two after the two multiple-choice questions. In general, these sentences mirrored information available in the multiple-choice questions and hence were not especially enlightening.

The consistency of the results across the two studies speaks for the usefulness of the technique for the investigation of component processes in skilled reading. Further explorations will be directed toward more detailed examination of factors such as length and difficulty of the text, familiarity of the target words, and extent of syntactic and semantic embeddedness of targets.

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